

EVALUATION OF THE LEDUC-STRATHCONA IMMITTANCE-HEARING SCREENING PROGRAM

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Submitted to:
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ABSTRACT

The present study critically reviews key aspects of the Leduc-Strathcona Immittance-Hearing Screening Program and formulates recommendations for improvement of the program. Areas examined include the program's pass-fail criteria, follow-up model and performance, information exchange, operation costs and data collection procedures. Such evaluation points out the practical problems encountered in the design, implementation and maintenance of large scale combined immittance-hearing screening programs.

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1.0 INTRODUCTION

Acoustic immittance measurements¹ are considered a valuable supplement to the traditional identification audiometry program. The inconsistent relationship between hearing loss and middle-ear disease requires the use of separate identification techniques. Combined acoustic immittance-pure-tone audiometry screening procedures thus constitute a comprehensive aural screening approach (Bluestone et al., 1973; McCandless and Thomas, 1974; Harker and Van Wagener, 1974; Jerger et al., 1974; Wilson, 1975; Cooper et al., 1975; Cody, 1977; Navarro and Klodd, 1978; ASHA, 1978; Northern, 1980; Ben-David et al., 1981).

Combined immittance-audiometric screening on a mass scale is limited in Alberta. The Leduc-Strathcona Immittance-Hearing Screening Program is the largest of its kind presently operating in the province. The Leduc-Strathcona program is designed to identify $4\frac{1}{2}$ to $5\frac{1}{2}$ year old children who are suspect of middle-ear pathology and/or hearing impairment for the purpose of providing follow-up diagnostic and remedial services. The program is administrated by the senior speech pathologist and engages eleven public health nurses as immittance-pure-tone screeners. All $4\frac{1}{2}$ to $5\frac{1}{2}$ year old children within the local health authority jurisdiction are routinely screened each year. Approximately half of this population receive combined immittance-pure-tone screening, while the remainder receive only pure-tone screening.

The present study critically reviews key aspects of the Leduc-Strathcona program and formulates recommendations for improvement of the program. Such evaluation provides the opportunity to examine the practical problems encountered in the design, implementation and maintenance of a large scale combined immittance-pure-tone screening program.

2.0 COMBINED ACOUSTIC IMMITTANCE-PURE-TONE AUDIOMETRY SCREENING

Support for the addition of acoustic immittance measurements to established pure-tone audiometry identification programs has been generated by heightened interest in the significance of middle-ear disease² and experimental evidence that demonstrates the relative lack of precision of pure-tone screening in its identification.³

Acoustic immittance measurements (particularly tympanometry and acoustic reflex) have been identified as powerful adjuncts to traditional methods used in the diagnosis of middle ear disease (Brooks, 1968; Jerger, 1970;

¹ Refer to Appendix 1.

² Refer to Appendix 2.

³ Refer to Appendix 1.

Jerger, 1974; Paradise et al., 1976; Brooks, 1977; Fernandes et al., 1978; Lampe et al., 1981). However, the efficacy of mass screening using acoustic immittance alone has been questioned since precise estimates of validity and reliability are difficult to establish (Harford et al., 1978). Brooks (1977) reported that although the predictive value of immittance measurements in the identification of middle-ear effusion is high (85% and above), the procedure can generate an undesirable level of over-referral. Swartz et al., (1978) concurred with this finding and proposed two main sources of over-referral: the capricious nature of middle-ear disease and conflicting evidence as to what constitutes abnormal middle-ear pressure.

Lewis (1975) and Schow and Yatamoto (1977) proposed a procedure to decrease the rate of over-referral found in conventional immittance screening. The procedure, termed "open-ended serial tympanometry", involves periodic retesting of selected failures over time until a pattern of failure is apparent. This ostensibly distinguishes persistent and serious cases from those that are mild and transitory by providing time for mild episodes to spontaneously resolve. In this way, over-referral is moderated. Brooks (1977) proposes a similar strategy but recommends one re-screen subsequent to failure performed after a six week interval.

While recognizing the need for a stronger research base in this area, the American Speech and Hearing Association published Guidelines for Acoustic Immittance Screening of Middle-Ear Disease in 1978. The guidelines include interim pass-fail criteria for the identification of middle-ear disease using tympanometry and acoustic reflex elicitation. The criteria incorporate an "at risk" category which requires the retesting of certain failures within a prescribed time period before further referral is initiated. In effect, this is a form of serial tympanometry which may reduce over-referral in the practical setting.

ASHA (1978) endorses the addition of immittance screening as an optional supplementary procedure to programs already undertaking pure-tone air conduction screening of school populations. Immittance measurement has several advantages as a screening approach: sound treated environments are not necessary, testing is rapid, no response is required from the individual being tested, the procedures are minimally limited by age and are useful for difficult to test individuals. McCandless and Thomas (1974) and Sitler, et al., (1976) estimate the average time requirement for administration of immittance screening to be approximately three minutes per subject. Thus, such measurements are easily incorporated into existing pure-tone hearing screening programs.

3.0 LEDUC-STRATHCONA IMMITTANCE-HEARING SCREENING PROGRAM: OVERVIEW

3.1 History

Immittance testing was first introduced in the Leduc-Strathcona Health Unit in 1975. At that time it was used in addition to pure-tone threshold testing as follow-up for failures identified by the existing hearing screening program. Immittance screening was added to the established hearing screening program on a limited

basis in 1978. Initial positive response to the program resulted in its gradual expansion. In March of 1980, the program was formalized and data collection for the purpose of future evaluation initiated.

3.2 Purpose

The Leduc-Strathcona program is designed to identify $4\frac{1}{2}$ to $5\frac{1}{2}$ year old children who are suspect of middle ear pathology and/or hearing impairment for the purpose of providing follow-up diagnostic and remedial services.

3.3 Program Objectives

1. To provide information in a form that is useful to those participating in and affected by the screening program (i.e. screeners, diagnostic personnel including physician and audiologist, parents and teachers).
2. To ensure that those tentatively identified by the screening measures receive appropriate follow-up including diagnostic and remedial services where indicated.
3. To maintain program data for the purpose of periodic evaluation to ensure that all aspects of the screening program will be open to positive change.
4. To promote primary preventive measures through health education.

3.4 General Features

3.4.1 Target Population

Combined immittance-hearing screening constitutes approximately one half of the total aural screening program for $4\frac{1}{2}$ to $5\frac{1}{2}$ year old children conducted by the Leduc-Strathcona Local Health Authority. The remaining half of this preschool population receive conventional pure-tone screening only.

The $4\frac{1}{2}$ to $5\frac{1}{2}$ year age group was chosen as a target population for combined screening since (1) the higher incidence of middle ear disease in young children is well documented (Brooks, 1978; McCandless and Thomas, 1974; Roberts, 1976), and (2) it is necessary to provide early intervention for disorders which may create serious language, educational, psychological and social problems (ASHA, 1978).

3.4.2 Personnel

The combined screening program is administrated by the senior speech pathologist whose responsibilities include: training and supervision of screeners, provision of follow-up testing,⁴ referral of identified cases to appropriate agencies and over-all monitoring of the program. Follow-up testing and referral is also provided by the speech pathology staff.

At present, eleven public health nurses conduct immitance-pure-tone screening. Screening staff are trained in groups of two-three in one day workshops conducted by the senior speech pathologist. Trainees must demonstrate competence in standard administration procedures for all measures and knowledge of prescribed pass-fail criteria and follow-up routes. Subsequent to the training workshop, all screeners receive supervision and support from the senior speech pathologist until confidence in all aspects of the procedures is expressed.

3.4.3 Equipment and Calibration

Five MADSEN ZS76 portable acoustic impedance bridges are used in the screening program. This model incorporates both acoustic immittance and pure-tone screen functions and conforms to specifications recommended by ASHA (1978).⁵ Follow-up pure-tone threshold testing is conducted at the health unit main and sub-offices using a BELTONE 12D audiometer and ECKEL'S 59s sound booth, both of approved standard.

All program equipment is calibrated yearly by an authorized service representative. Daily checks and calibration of the impedance bridge pressure indicator (manometer zero) and compliance volume is conducted, the latter using a three cubic centimeter cavity which also provides a monitor of the air system. The pure-tone component of the ZS76 is informally checked daily by having the screener conduct a pure-tone self-screen prior to testing.

⁴ Follow-up testing conducted by the speech pathology staff is in no way considered diagnostic. This testing is in effect a re-screen using tympanometry and air/bone conduction threshold testing for the purpose of providing additional referral information to the physician and audiologist.

⁵ See Appendix 3.

⁶ See Appendix 4: One standard form records screening results, the other follow-up test results.

3.4.4 Records

Two standard forms are used in recording screening and follow-up test results.⁶ A copy of each screening test form completed is to be forwarded to the senior speech pathologist. Referral for follow-up testing is accompanied by a copy of screening results. A file is created and maintained by the Speech Pathology Program for each case referred for follow-up testing. Results of follow-up testing and additional information are documented using the standard "Audiology Report Form".

3.5 Procedures

Screening measures include otoscopic examination, pure-tone air conduction screening and tympanometry. Screening is largely conducted in a school setting since the majority of children tested attend Early Childhood Services Programs. Follow-up testing consists of re-administration of tympanometry and performance of pure-tone air/bone conduction threshold testing. This is performed by the senior speech pathologist (or speech pathology staff) at the health unit and sub offices. Standard approved procedures are employed.

3.5.1 Otoscopic Examination

Otoscopic examination is conducted as a check for infection, myringotomy, foreign objects, excessive wax or debris. If any of these conditions exist, tympanometry is not performed on that ear.

3.5.2 Pure-Tone Air Conduction Screening

Procedures used in pure-tone air conduction screening conform with ASHA (1974) guidelines. Test frequencies include 1000Hz, 2000Hz and 4000Hz screened at 20dBHL, or 4000Hz at 25dBHL. Any failure to respond at any frequency is considered a failure and immediate re-screening is performed following repositioning of earphones and careful re-instruction. Failure at any frequency of the immediate re-screen constitutes a screening failure. Follow-up procedures for pure-tone screening failures are summarized in Figure 1.

3.5.2 Tympanometry and Acoustic Reflex

Tympanometry and acoustic reflex elicitation are performed in accordance with procedures outlined in the MADSEN ZS76 Manual. Acoustic reflex is performed contralaterally at 1000Hz at 100dBHL. A standard tympanogram is recorded and note is made of the presence or absence

of the acoustic reflex for both ears. Pass-fail criteria are solely based on measurement of peak middle-ear pressure. Peak pressure of ± 100 mm water for both ears constitutes a pass. Measurements obtained outside this range or absence of a compliance peak for either ear are considered at risk or failures. Acoustic reflex results are recorded as supplementary information and not included in the pass-fail criteria. Details of the criteria and follow-up routes for tympanometry are summarized in Table 1.

3.6 Pass-Fail Criteria and Follow-Up Model: Comparison and Rationale

The pass-fail criteria and follow-up model presented in Table 1 were developed prior to the publication of the ASHA (1978) guidelines for impedance screening and are thus not entirely consistent with them. The criteria adopted by the Leduc-Strathcona program were based on literature available at the time and practical experience with the problem of over-referral. Table 2 compares the Leduc-Strathcona guidelines with those recommended by ASHA (1978). The guidelines differ mainly in (1) the factors considered in the referral criteria, (2) criteria for normal peak middle-ear pressure, and (3) number of re-tests for cases deemed "at risk".

Although recorded, acoustic reflex results are not presently considered in the Leduc-Strathcona referral criteria. The original criteria developed by the program did include these measurements but a high rate of over-referral was found for cases failed due to the absence of acoustic reflex. Some literature has suggested that acoustic reflex may be an overly sensitive measure for screening purposes (Renvall, 1975; Brooks, 1973) and Roberts (1976) recommended that absence of acoustic reflex in the presence of Type A tympanogram (normal) not be included in criteria defining abnormality for screening purposes. Brooks (1977) proposed tympanometry with a defined curve criterion as an acceptable screening alternative to measurement of acoustic reflex. Cody (1977) also reported two screening programs that used peak middle-ear pressure in combination with pure-tone screening with favorable results. Based on such information, acoustic reflex was deleted from the combined screening program at Leduc-Strathcona.

The criteria defining normal peak middle-ear pressure employed by the Leduc-Strathcona program (± 100 mm to -100 mm water) are more sensitive than those recommended by ASHA (± 100 mm to -200 mm water). At the time the program was initiated, the literature was not unanimous regarding the lower limit of normal peak pressure. Berry et al. (1975) and Cooper et al. (1975) recommended -100 mm water while others, including Walton (1975) and Sitler et al. (1976) proposed -150 to -200 mm water as a negative pressure cut off. The Leduc-Strathcona program favored the more sensitive criterion and -100 mm water was adopted as an interim value.

Finally, the two sets of guidelines differ in the number of re-tests conducted for initial test "at risk" cases. ASHA recommends immediate referral to the physician for "at risk" cases who do not meet pass criteria upon re-screen. Leduc-Strathcona interpose an additional re-test consisting of tympanometry and air-conduction pure-tone threshold testing (termed "follow-up testing") before referral to the physician is made in such cases. Cases directly referred out are only those who fall into the "fail" category (i.e. peak pressure outside -400 mm water or no compliance peak).

TABLE 1

Pass-Fail Criteria and Follow-up Model

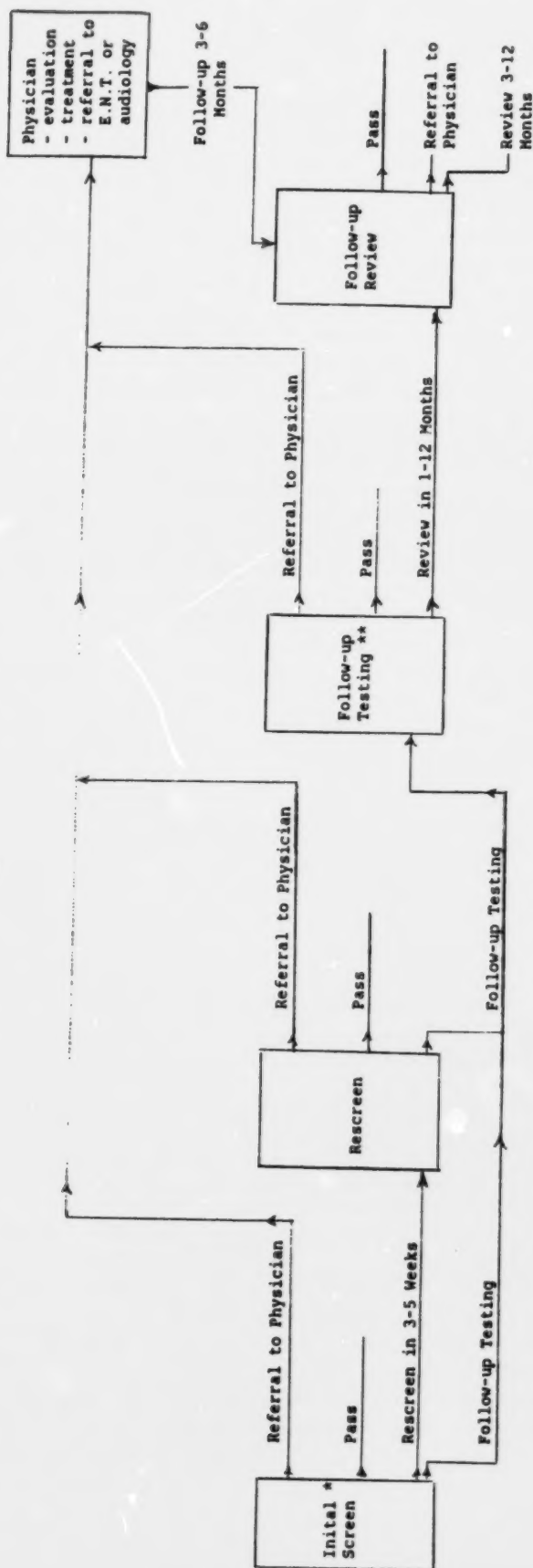
Classification	Results of Initial Screen	Disposition
I. PASS	Middle-ear Pressure: ± 100 mm H ₂ O and Hearing Screen Pass	CLEARED: NO RETURN
II. AT RISK	Middle-ear Pressure: -101 to -200 mm H ₂ O and Hearing Screen Pass or Fail, or Middle-ear Pressure: -201 to -400 mm H ₂ O and Hearing Screen Pass or Middle-ear Pressure: -201 to -400 mm H ₂ O and Hearing Screen Fail	RETEST IN 3-5 WEEKS a) If tympanogram and hearing screen = CLASS I, PASS; b) If tympanogram and hearing screen = CLASS II, REFER IMMEDIATELY FOR FOLLOW-UP TESTING c) If tympanogram and hearing screen = CLASS III, REFER IMMEDIATELY TO PHYSICIAN AND FOLLOW-UP TESTING. REFER IMMEDIATELY FOR FOLLOW-UP TESTING*
III. FAIL	Middle-ear Pressure: outside -400 mm H ₂ O (or no compliance peak) and Hearing Screen Pass or Fail	REFER DIRECTLY TO PHYSICIAN** AND FOLLOW-UP TESTING

* Follow-up testing consists of readministration of tympanometry and administration of pure-tone air/bone conduction threshold testing.

** Referral to physician includes recommendation for further referral to audiologist for diagnostic evaluation if hearing loss is also suspected.

FIGURE 1

PROGRAM MODEL



* Screen and Re-screen - Nursing Staff

** Follow-up - Speech Pathology Staff

TABLE 2

Comparison of Pass-Fail Criteria and Follow-up Model:
ASHA (1978) and Leduc-Strathcona

	Asha	Leduc-Strathcona
1. Factors Considered	Peak middle-ear pressure Acoustic reflex	Peak middle-ear pressure Hearing screening results
2. Pass Criteria (Immittance)	Peak pressure within range of +100 to -200 mm AND acoustic reflex present	Peak pressure within range of +100 mm water AND hearing screen pass.
3. At Risk Criteria	Peak pressure outside +100 to -200 mm water OR absence of acoustic reflex ACTION: RETEST IN 3-5 WEEKS	Peak pressure -101 to -200 mm water (regardless of hearing screen result) OR Peak Pressure -201 to -400 mm water and hearing screen pass. ACTION: RETEST IN 3-5 Weeks, OR Peak Pressure -201 to -400 mm water AND hearing screen fail ACTION: REFER IMME- DIATELY FOR FOLLOW-UP TESTING
4. Fail Criteria	Peak pressure outside +100 to -200 mm water AND absence of acoustic reflex ACTION: REFER FOR FURTHER EVALUATION	Peak pressure outside -400 mm water (including no compliance peak) ACTION: REFER DIRECTLY TO PHYSICIAN AND FOLLOW- UP TESTING

4.0 OBJECTIVES OF THE PRESENT STUDY

The purpose of the present study is to critically review key features of the Leduc-Strathcona Immittance-Hearing Screening Program and to formulate recommendations for improvement of the program. Specific objectives of the evaluation are provided below and are based on criteria defined for effective health and educational screening outlined by Lessler (1972):

1. To determine whether effective exchange of information occurs among those participating in the program.
2. To determine whether those tentatively identified receive appropriate follow-up services administered within the timelines specified by the program guidelines.

3. To review the prescribed pass-fail criteria and re-test timelines in light of available data.
4. To determine actual costs for operation of the screening program.
5. To provide statistics descriptive of program performance and screening outcome for the study sample.
6. To determine whether records maintained on an ongoing basis provide for adequate documentation and retrieval of required client and program data.

5.0 METHOD

5.1 Subjects

The study sample consisted of those 4½ to 5½ year old children who received combined immittance - pure-tone screening under the jurisdiction of the Leduc-Strathcona Local Health Authority from March, 1980 to July 1981 for whom complete initial screening results were available. Complete initial screening results were defined as having (1) name, (2) date of birth, (3) date of administration, (4) pure-tone results for both ears, and (5) immittance results for both ears. Pure-tone and immittance results were considered complete if in the absence of actual measurements, the reason for inability to test (e.g. inability to obtain probe seal or inconsistent response) was recorded.

Based on these criteria, 1,149 children were included in the study sample. Subjects were nearly equally distributed by sex (males: 53.4%; females: 46.6%).

5.2 Data Collection and Analysis

Existing standard client records on file at Leduc-Strathcona formed the primary data source for the evaluation. Further information was obtained by interview and questionnaire. The client record forms and screener questionnaire appear in Appendices 4 and 5, respectively. Data selected from the client records for purposes of the evaluation is summarized in the following section. This information was coded for computer analysis which consisted of simple frequency and cross-tabulations. Basic descriptive statistics were also calculated for a number of factors.

5.3 Selected Client Data

Data was selected from existing client records at four points in the program sequence: initial screen, re-screen, initial follow-up, and final review. Four main factors were included:

1. sex
2. date of test administration
3. pure-tone results for both ears
4. immittance results for both ears
5. recommended action or disposition

Pure-tone results for initial screen and re-screen were recorded as pass-fail. Follow-up pure-tone results consisted of the pure-tone threshold average of 500 Hz, 1000 Hz and 2000 Hz. Immittance results for both screen and follow-up testing consisted of peak middle-ear pressure in millimeters of water.

6.0 RESULTS AND DISCUSSION

6.1 Objective 1

To determine whether effective exchange of information occurs among those participating in the program.

In meeting this objective, information exchange occurring between the following groups was reviewed through the screener questionnaire⁸ and interview with the senior speech pathologist:

Screening and Follow-Up Personnel

Screening personnel are responsible for maintaining local records on all cases screened. A listing of all screening passes and failures is provided to the senior speech pathologist and copies of all screening forms completed are also eventually forwarded. This transfer is not conducted on a set schedule per se but occurs on an ongoing basis throughout the year. In addition, "at risk" cases requiring follow-up testing and cases referred directly to the physician are referred to the speech pathology program via a standard referral form. Speech pathology staff in turn provide written or verbal feedback to screeners regarding follow-up test results and disposition of cases referred.

Five of six screeners surveyed indicated that sufficient feedback regarding cases referred was provided by follow-up staff. One respondent indicated insufficient feedback was received on cases referred who did not receive follow-up testing due to parent refusal, cancellation or no show.

Screening/Follow-up Personnel and Parents/Teachers

Screeners are responsible for contacting parents and teachers of children "at risk" or failing initial or re-screening. The mode of reporting such information is left to the screener's discretion. Responses to the Screener Questionnaire indicated that:

- 1.. The majority of screeners (5 of 6 surveyed) contact parents upon initial screening failure; one screener reported contacting parents only if referral for follow-up or diagnostic testing was indicated.
2. All screeners surveyed routinely contact parents upon re-screen failure.

3. Information is reported to parents either by telephone (2) or by note followed by telephone call (3).
4. All screeners surveyed routinely contact teachers upon initial and re-screen failure.
5. Information is reported to teachers verbally and followed by a listing of all passes/failures (6).

Follow-up personnel usually have face to face contact with parents of children referred for follow-up since such testing is conducted at the health unit office. Results are explained in detail at the time of testing. The senior speech pathologist reported some lack of consistency in reporting of follow-up results to teachers. When provided, such information can be reported verbally or in written form.

Screening/Follow-up Personnel and Diagnostic Personnel

Both screening and follow-up personnel can refer cases directly to the family physician. Where suspected hearing loss accompanies immittance failure, referral to the physician includes a request for the physician to refer the child on for diagnostic audiological evaluation. When a screener makes a direct referral to the physician, follow-up personnel (usually the senior speech pathologist) are to be notified via the standard referral form. The following methods of providing information to the family physician were used by the screeners surveyed and are identical to those employed by follow-up personnel:

1. Parent advised to have child examined by the family physician and provided with written results/referral to present to the physician (4).
2. Parents advised to have child examined by the family physician and written results/referral mailed to physician (2).

Feedback provided by the physician regarding cases referred was found to be inconsistent by both screeners and follow-up personnel. Whether feedback is forth-coming appears to depend on the individual physician consulted. Interview with the senior speech pathologist revealed that the program receives written feedback from some physicians; however, in many cases follow-up personnel must attempt to ascertain the outcome of medical examination from the parent. In addition, results of audiological evaluation are not generally directed to the program since it is the physician who must initiate the referral. Local audiological facilities do provide written feedback on cases referred by the program on request.

Summary

It is apparent from the above review that the Leduc-Strathcona program has identified the necessary lines of communication among persons responsible for and affected by the program. The main problem afflicting this aspect of the program appears to be the consistency with which exchange of information occurs. The following weaknesses were identified:

1. Screening records provided by screeners to follow-up personnel are in some cases incomplete.
2. Not all screeners receive adequate feedback regarding cases referred for follow-up testing who did not receive such testing due to parent refusal, no-show or cancellation.
3. Not all screeners routinely contact parents upon initial screen failure.
4. Feedback provided to teachers by follow-up personnel is inconsistent.
5. Physicians do not consistently provide feedback to program personnel regarding the disposition of cases referred.
6. The program guidelines do not stipulate standard modes for reporting information to parents and teachers.

6.2 Objective 2

To determine whether those tentatively identified receive appropriate follow-up services administered within the timelines specified by the program guidelines.

In meeting this objective, three main questions were investigated through analysis of client data, screener questionnaire and interview with the senior speech pathologist:

1. What proportion of cases identified receive appropriate follow-up services?
2. What proportion of cases receive such services within the timelines specified by the program guidelines?
- 3.. What factors preclude or delay the provision of follow-up services?

Emphasis has been placed on verifying whether follow-up services for which the program is responsible (re-screening and follow-up testing) have been provided and within what time period. Available data did not permit an accurate accounting of whether recommended services administered outside the program (medical examination) occurred.

Follow-up Subsequent to Initial Screen

A total of 344 children failed or were found to be "at risk" upon initial screening. This represents 29.9 percent of the total sample of 1,149 children. Table 3 presents a breakdown of the follow-up services recommended in accordance with the program guidelines for this group. To determine whether the children received the recommended follow-up, actual services received subsequent to initial screening were verified for each case. This information is summarized in Tables 4a and 4b. Of the 344 cases identified as "at risk" or failure upon initial screening, 156 (45.3%) received the follow-up services* recommended. No recorded follow-up could be found for 125 (36.3) cases and 63 (18.3) children received services other than those recommended.

TABLE 3
Initial Screen: Follow-up Recommended
For Cases "At Risk" or Failed (N=344)

Recommended Follow-up Testing	Number of Cases	%	% of Total Sample (N=1149)
Re-screen	255	74.1	22.2
Refer directly to physician and follow-up testing	54	15.7	4.7
Refer directly for follow-up testing	24	7.0	2.1
Review on request - presently under care	11 (344)	3.2 (100.0)	0.9 (29.9)

* Refers to services administered through the program. This figure includes eleven cases who received no further action since they were currently under medical care.

TABLE 4a
Services Received by Cases Recommended
For Re-Screen (N=255)

Follow-up Received	Number of Cases	%
Re-screen	125	49.0
Received Follow-up Testing	20	7.8
No Action Recorded	110	43.1

TABLE 4b
Services Received by Cases Recommended
For Physician Referral and/or Follow-up Testing (N=78)

Follow-up Received	Number of Cases	%
Re-screen	43	55.1
Received Follow-up Testing	20	25.6
No Action Recorded	15	19.3

A total of 168 children were re-screened which represents 14.6 percent of the total sample (N=1149). It should be noted, however, that 43 of these cases received re-screening when other services were recommended. In fact, a total 125 appropriate re-screens were conducted which represents 49 percent of all cases recommended for re-screen (N=255) and 10.9 percent of the total sample (N=1149).

The program guidelines stipulate that re-screening of initial "at risk" cases should be completed within three to five weeks from the time of initial screening. Table 5 provides a breakdown of the time interval in weeks between initial and re-screening for this group. Time between the two screenings was found to range from one to 63 weeks, with an average interval of 13 weeks. Overall, 42 (25.0%) cases were re-screened within the recommended period.

TABLE 5
Time Lapse Between Initial and Re-Screen:
Number and Percent of Cases Re-screened Within
Specified Weeks of Initial Screen (N=168)

Re-screened Within (Weeks)	Number of Cases	%	Cumulative %
1 - 5	42	25.0	25.0
6 - 7	36	17.9	42.9
8 - 10	16	9.5	52.4
11 - 15	40	23.8	76.2
16 - 20	9	5.4	81.5
21 - 35	24	14.3	95.8
36 - 63	7	4.2	100.0
	(168)	(100.0)	

A total of 40 children received follow-up testing directly subsequent to initial screening failure (includes "at risk" cases). It should be noted that this includes 20 cases who received follow-up testing when re-screening was recommended. As shown in Table 4b, 20 cases appropriately received follow-up testing directly subsequent to initial screening. This represents 25.6 percent of all cases recommended and 1.7 percent of the total sample.

Table 6 presents the time lapse in weeks between initial screen and follow-up testing. Reported intervals ranged from one to 60 weeks, with an average lapse of 14 weeks. Overall, 19 (47.5%) cases received follow-up testing within eight weeks of initial screening.

TABLE 6
Time Lapse Between Initial Screen and Follow-up
Testing: Number and Percent of Cases Receiving Follow-up
Testing Within Specified Weeks of Initial Screen (N=40)

Follow-up Testing Within (Weeks)	Number of Cases	%	Cumulative %
1 - 4	11	27.5	27.5
5 - 8	8	20.0	47.5
9 - 16	7	17.5	65.0
17 - 24	8	20.0	85.0
25 - 32	1	2.5	87.5
33 - 60	5	12.5	100.0
	(40)	(100.0)	

Follow-up Subsequent to Re-Screen

A total of 80 children failed or were "at risk" upon re-screening. This represents 47.6 percent of all cases who received re-screening (N=168) and seven percent of the total sample (N=1,149). It should

be noted that seven percent is considered an estimate of the re-screen failure rate for the total sample since 43 percent of cases recommended for re-screening were not tested.

Table 7 summarizes the follow-up services recommended for cases failed or "at risk" upon re-screening. A total of 75 (93.8%) cases were recommended for follow-up testing. Of this group, 40 (53.3%) cases received follow-up testing as recommended while no record of services received was found for 35 (46.7%) children. Table 8 presents the time lapse in weeks between re-screen and follow-up testing. Intervals ranged from one to 30 weeks, with an average lapse of eight weeks. Overall, 28 (70.0%) cases received follow-up testing within eight weeks of re-screen.

TABLE 7
Re-Screen: Follow-up Recommended for Cases
"At Risk" or Failed (N=80)

Recommended Follow-up	Number of Cases	%
Refer for follow-up testing	50	62.5
Refer directly to physician and follow-up testing	25	31.3
Review on request - presently under care	5	6.2
	(80)	(100.0)

TABLE 8
Time Lapse Between Re-Screen and Follow-up Testing:
Number and Percent of Cases Receiving Follow-up
Testing Within Specified Weeks of Re-Screen (N=40)

Follow-up Testing Within (Weeks)	Number of Cases	%	Cumulative %
1 - 4	17	42.5	42.5
5 - 8	11	27.5	70.0
9 - 12	2	5.0	75.0
13 - 16	3	7.5	82.5
17 - 30	7	17.5	100.0
	(40)	(100.0)	

Services Provided After Initial Follow-Up Contact

A total of 49 children failed or were "at risk" upon initial follow-up testing. This represents 61.3 percent of all cases who received follow-up testing (N=80) and 4.3 percent of the total sample. Again, 4.3 percent is an estimate of follow-up test failure rate for the total sample since 34.0 percent of cases recommended were not tested.

Table 9 summarizes the follow-up recommended for cases failed or "at risk". Overall, it was found that 16 (32.7%) cases recommended for referral and/or review received such services. However, verification of services received is complicated by the fact that reviews can be scheduled from three to 12 months from the time of initial follow-up. Thus, several cases may correctly be awaiting review. The time lapse found between initial follow-up and review ranged from five to 27 weeks, with an average interval of 14 weeks.

TABLE 9
Initial Follow-up: Services Recommended
For Cases Failed (N=49)

Services Recommended	Number of Cases	%
Review in 3 - 12 months	16	32.7
Refer to physician and review in 3-12 months	25	51.0
Review on request - presently under care	8 (49)	16.3 (100.0)

Summary: Factors Precluding or Delaying the Provision of Follow-up Services

It is apparent from the preceding review that:

- 1) a high proportion of cases identified as "at risk" or failure did not receive recommended follow-up services, and
- 2) when provided, such services did not occur for the majority of cases within the timelines prescribed by the program guidelines.

Factors to account for these findings were investigated. The observed delay in re-screening can be mainly attributed to the fact that aural screening is but one of the total program of services provided by nursing staff. Screeners surveyed indicated that re-screening is conducted within the set schedule of school visits. Delays are imposed when scheduled visits are cancelled for various reasons, testing space is unavailable, or when children are absent. In such cases, re-screening is postponed until the next school visit. Reasons why a high proportion of cases did not receive re-screening as recommended are not clear. Possible explanations include: staff turnover, lack of adequate records, high service demand, low priority of screening, attrition, and incomplete understanding of the screening criteria. It is likely that a combination of such factors produced the observed level of missing re-screens.

Information is available to account for the high percentage of children who did not receive follow-up testing as recommended. Existing records were traced on 62 children recommended for follow-up testing who did not receive these services. It was found that in 54.8 percent of cases, no record of referral for follow-up existed; 19.4 percent refused services since the child was already under medical care; 14.5 percent failed to keep the appointment scheduled; 11.3 percent could not be contacted to schedule on appointment.

The observed time lapse between initial or re-screening and follow-up testing is best explained by examining the sequence of events that must precede actual testing. Upon failure, screeners must obtain permission from parents to initiate referral for follow-up testing. Test results and the standard referral form must then be forwarded to the speech pathology program. Upon receipt, parents must again be contacted and an appointment scheduled. Any breakdown in this chain of events can result in the delay or preclusion of testing.

6.3 Objective 3

To review the pass-fail criteria and re-test timelines in light of available data.

Pass-Fail Criteria

To accurately determine the validity of the pass-fail criteria employed by the program, estimates of over and under-referral rates must be made. To do this, the true disposition of cases identified must be verified.* In the case of immittance screening, true disposition is established through medical examination for middle ear disease. Unfortunately, such information was not available from existing client records, the study's sole data source. As a result, the literature was consulted to review immittance criteria proposed by similar programs for which over-referral rates have been estimated. Of particular interest was the negative cut-off value for abnormal peak middle-ear pressure used. One such study is reported by Cody (1977). Criteria employed by the program described are very similar to those of Leduc-Strathcona. Differences noted included (1) inclusion of cases with physical volume of greater than 5.0cc as failure regardless of pure tone results, and (2) the specified cut-off for abnormal peak middle ear pressure (-150 mm to -250mm "at risk"). At risk cases not passing re-screen were referred for medical examination. Table 10 presents the disposition of cases referred and indicates an over-referral rate of approximately 14 percent. ASHA (1978) recommends -200mm as the negative cut-off for normal peak pressure to avoid over-referral.

* Such information is well established in the case of pure-tone screening and is not of great concern here since the program employs generally accepted criteria.

Leduc-Strathcona employs -100mm of water as the negative cut-off for normal peak pressure which accounts for the high number of cases identified as "at risk" upon initial screening. Table 11 shows that 61.1 percent of cases identified as failures or "at risk" did not pass immittance screening. This represents 18.3 percent of the total sample. Table 12 indicates that 49.1 percent of all ears identified as "at risk" fell into the -100 to -200mm range of peak pressure. This represents 7.4 percent of the total sample. Had -200mm been used as the normal cut-off value, the total number of cases identified as "at risk" or failure would have been reduced by 6.0 percent for the study sample. This is illustrated in Table 13. Upon further analysis it was also found that 67.2 percent of cases identified as "at risk" in the -101 to -200mm range passed re-screening conducted within three to eight weeks of initial screen.

TABLE 10
Cody (1977): Disposition of Failures Referred
for Medical Examination (N=267)

Failure Type	Normal Ent	Ent Problem
Tympanometry only	23	158
Pure-tone only	10	19
Tympanometry and pure-tone	5 (38)	52 (229)

TABLE 11
Leduc-Strathcona: Initial Screen Cases Identified
"At Risk" or Failure by Type (N=344)

Failure Type	Number of Cases	% of Total Failed	% of Total Sample (N=1,149)
Audiometry only	81	23.5	7.0
Immittance only	119	34.6	10.4
Audio and Immittance	91	26.5	7.9
Incomplete*	53 (344)	15.4 (100.0)	4.6 (29.9)

* Cases that could not be classified since results on both types of tests were not provided due to lack of co-operation, failure to get seal, etc.

TABLE 12
Leduc-Strathcona: Initial Immittance Screen Results
Reported in Peak Middle-Ear Pressure for
Ears Screened (N=2,298)

Immittance Result	Number of Ears	% of Total Ears Failed or At Risk	% Total Sample
Pass (-100mm)	1,914	-	83.3
At risk (-101 to -200mm)	171	49.1	7.4
At risk (-201 to -400mm)	87	25.0	3.8
Failure (less than -400mm or no compliance peak)	90	25.9	3.9
Could not obtain seal	16	-	0.7
Would not cooperate	9	-	0.4
Tubes/Myringotomy/Infection	11 (2,298)	- (100.0)	0.5 (100.0)

TABLE 13
Leduc-Strathcona: Initial Screen Cases Failing or
"At Risk" When Normal Peak Pressure Cut-Off = -200mm

Failure Type	Number of Cases	% of Total Failed Cases	% of Total Sample
Audiometry only	112	40.6	9.7
Immittance only	51	18.5	4.4
Audio and Immittance	60	21.7	5.2
Incomplete	53 (276)	19.2 (100.0)	4.6 (23.9)

Re-test Timelines

The re-test timelines employed by Leduc-Strathcona are identical to those recommended by ASHA (1978). Initial screen "at risk" cases are to be re-screened within three to five weeks. Data presented in Section 5.2 has shown that re-screening occurred within the prescribed timelines for only 25 percent of cases. Reasons for delays in re-screening have been discussed and are related to operational problems of scheduling and screener work-load. Further, it is significant that initial screening is conducted mainly during October and November. Due to this, re-screening may be delayed by the school Christmas vacation.

Summary

It is apparent from the preceding review that the criteria used by Leduc-Strathcona for the identification of "at risk" cases in immittance screening (peak pressure outside $\pm 100\text{mm}$) is too sensitive and results in a high number of cases being referred for re-screening. This adds to the already difficult task of re-screening cases identified within the three to five week timeline recommended by ASHA (1978).

6.4 Objective 4

To determine actual costs for operation of the screening program.

In estimating actual costs for operation of the screening program, three main factors were considered: 1) equipment purchase and maintenance, 2) training time, and 3) test administration time for screening and follow-up. It should be noted that the total estimate reflects the cost of the combined immittance-pure-tone program rather than the cost of immittance screening alone. Further, training and test administration time is allocated within the existing speech pathology and nursing programs.

1) Equipment and Calibration Costs

The program employs the MADSEN ZS76 portable impedance bridge which incorporates both immittance and pure-tone functions:

Five units @ \$1,995.00 = \$9,975.00

Each unit is calibrated yearly by the manufacturer's authorized service representative.

Five units @ \$70.00 = \$350.00

Total cost of equipment purchase and maintenance: \$10,325.00.

2) Training Costs

Thirteen nurses were trained in test administration procedures by the senior speech pathologist. One day workshops were conducted with groups of three nurses and the senior speech pathologist subsequently provided follow-up instruction to all nurses trained.

Time expended by the senior speech pathologist in training screeners was estimated at 121 hours, comprised of 30 hours in workshops and 91 hours follow-up:

121 hours @ \$13.00 per hour = \$1,573.00

Time expended by nursing personnel was estimated at 14 hours per nurse trained, comprised of seven hours in workshop and seven hours follow-up:

182 hours @ \$13.00 per hour = \$2,366.00

Total cost of training = \$3,939.00

3) Test Administration Costs

a) Initial Screening

Time required to perform combined immittance-pure-tone testing is estimated at nine minutes per child, comprised of two minutes preparation, five minutes administration and two minutes charting. The average hourly wage for nurses conducting screening was estimated at \$13.00 per hour. Thus, the cost of initial screening is estimated at \$1.95 per child. However, this cost increases to \$4.77 per child if referral to the physician and/or follow-up testing is indicated. This increase in cost results from the additional time (12 minutes per child) expended in contacting parents and completing the paperwork required for referral.

A total of 1,149 initial screenings were conducted, of which 78 required referral to the physician and/or follow-up testing:

1071 children screened @ \$1.95 per child = \$2,088.00

78 children screened @ \$4.77 per child = \$372.00

Total cost of initial screening: \$2,460.00.

b) Re-Screening

Costs per child screened are identical to those estimated for initial screening.

A total of 168 children were re-screened, of which 75 required referral to the physician and/or follow-up testing:

93 children re-screened @ \$1.95 per child = \$181.00

75 children re-screened @ \$4.77 per child = \$358.00

Total cost of follow-up testing: \$539.00

c) Follow-up Testing

Time required to perform follow-up testing was estimated at thirty minutes per child. The average hourly rate for speech pathology staff conducting follow-up testing was estimated at \$13.00.

A total of 80 children received follow-up testing.

80 children @ \$6.50 per child = \$520.00

Total cost of follow-up testing = \$520.00

Summary

Total costs for operation of the Leduc-Strathcona program are summarized as follows:

Equipment purchase and maintenance	\$10,325
Training	3,939
Initial Screening	2,460
Re-Screening	539
Follow-up Testing	520
	<u>\$17,783</u>

When considering the above figure three factors should be noted. First, the greatest cost to the program lies in the initial purchase of equipment. Cooper (1975) estimated the average life of equipment to be eight to ten years. Secondly, the test administration costs for screening and re-screening reflect the total cost of both immittance and pure-tone screening. Immittance screening adds approximately three minutes or \$0.65 per child screened to the administration cost of existing pure-tone screening. Thirdly, the use of -200 mm peak middle-ear pressure as the negative cut-off value would have reduced the number of required re-screenings by approximately six percent.

6.5 Objective 5

To provide statistics descriptive of program performance and screening outcome for the study sample.

All statistics relevant to the above objective appear in Appendix 6.

6.6 Objective 6

To determine whether records maintained on an ongoing basis provide for adequate documentation and retrieval of required program and client data.

In meeting this objective, the content and format of the screening and follow-up test forms were examined. Copies of each appear in Appendix 4.

The standard screening form employed by the program is maintained locally by the screeners. It is the sole record of cases screened and all forms completed are eventually forwarded to the senior speech pathologist. When follow-up testing is indicated, a copy of the screening form accompanies the referral form. In addition, a list of screening passes and failures is compiled for school personnel and the senior speech pathologist.

Upon review, the content of the screening form was found to provide an adequate profile of the child's relevant personal data and test results. However, a distinct category is not provided for recording 1) disposition or recommended follow-up (e.g. re-screen), or 2) follow-up services received or outcome of medical examination. Relevant to the latter point, it was found that a standard means of requesting information from outside agencies and physicians regarding the disposition of cases referred is not employed by the program.

Content of the standard form employed by the speech pathology staff to record follow-up test results was found to provide an adequate profile of cases tested. No additional categories appear necessary at this time.

In general, the format of the screening and follow-up forms appears to be adequate for maintaining local records on individuals tested. However, the existing format does not facilitate easy tabulation of program data. In fact, the program does not employ a standard means and schedule for compiling summary data for the purpose of program review. Lack of such information hampers effective monitoring of the program.

7.0 CONCLUSIONS

The present study has reviewed the design and maintenance of the Leduc-Strathcona Immittance and Hearing Screening Program in an attempt to identify apparent weaknesses and provide direction for positive change. The main findings of the study are as follows:

1. Inconsistency is apparent in the exchange of information that occurs among screeners, follow-up staff, physicians, parents and teachers. Such inconsistency adversely affects the accuracy of records, continuity of service and the satisfaction of those providing or receiving services.
2. A high proportion of children identified do not receive recommended follow-up services that are under the direct control of the program.
3. A high proportion of children identified do not receive recommended follow-up services within the timelines prescribed by the program guidelines.
4. The criterion defining the immittance "at risk" category (peak pressure outside ± 100 mm) is more sensitive than that recommended by ASHA (1978) and results in an unnecessarily high referral rate for re-screening. Such additional service demands compound the already difficult task of re-screening cases within the prescribed timelines.
5. A standard and efficient means of compiling individual client data for the purpose of program review is not employed by the program. Lack of such summary information hampers effective program monitoring.

8.0 RECOMMENDATIONS

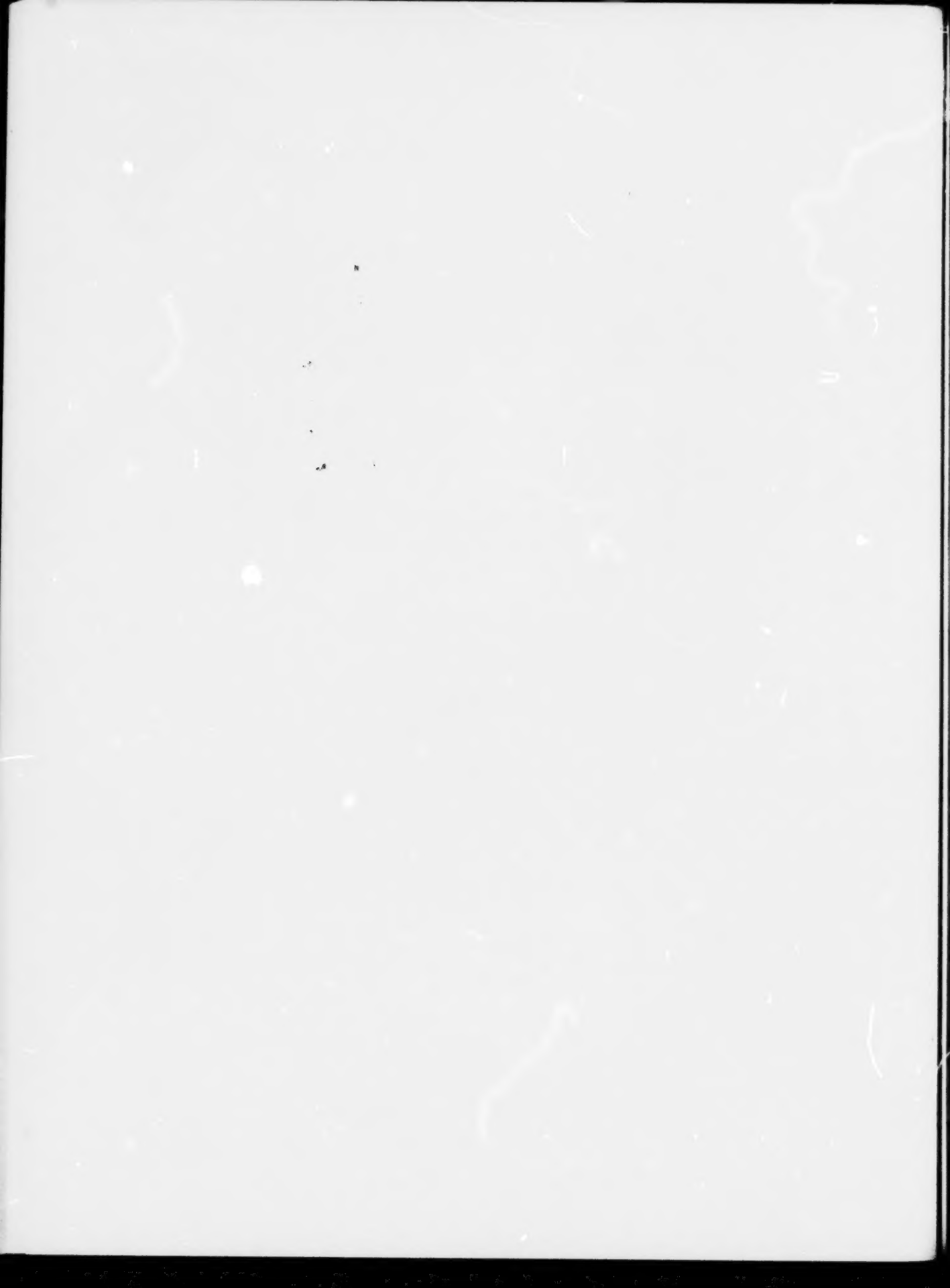
The following recommendations address the main findings of the present study as outlined above. Further recommendations regarding technical aspects of the program appear in Appendix 7.*

1. The program should attempt to standardize procedures for information exchange. Specific guidelines should be developed stipulating individuals that should receive information regarding screening and follow-up outcome, when such information should be provided and a standard content and format for such information transfer.
2. The program should develop a standard and systematic means of summarizing individual client data for the purpose of program review. Present record forms should be modified to permit easy tabulation of such data. Further, methods to obtain complete records on services provided to clients outside the program (e.g. medical or audiological evaluation and treatment) should be investigated.

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These recommendations were provided by Dr. Paul Kileny, Chet DesRoches and Ned Kramp. Appreciation is expressed for their cooperation and assistance.

3. Specified program objectives should include operational goals for program performance. Areas in which such targets would apply include: 1) proportion of cases expected to receive appropriate follow-up services provided by the program (i.e. re-screening, follow-up testing), and 2) proportion of cases to receive appropriate follow-up with the timelines prescribed.
4. Increased and systematic monitoring of the program is recommended. Means of improving the effectiveness of program review include (1) introducing a set format and schedule for provision of program data, (2) regular contact with screening personnel to review program goals and performance, to discuss problems and concerns, etc.
5. The program should revise its imittance pass-fail criteria in order to more closely approximate ASHA (1978) guidelines and as a means of reducing the number of unnecessary re-screens. Specific guidelines appear in Appendix 7.
6. The program should investigate ways in which to facilitate the provision of follow-up services within acceptable time frames. Possible methods include (1) the prioritization of re-screens, (2) having nurses block-schedule screening within their program.
7. The program should prepare a procedures manual which describes in detail all aspects related to the operation of the program including program objectives, performance goals, division of responsibilities, standard reporting and recording procedures, pass-fail criteria, follow-up routes, and referral procedures. Such a manual would prove a valuable resource in training and would provide program staff with a complete guideline for continuing reference.
8. Finally, it is recommended that the present program not be expanded until steps can be taken to consolidate and incorporate some or all of the above recommendations.



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APPENDIX 1
ACOUSTIC IMMITTANCE MEASUREMENTS



ACOUSTIC IMMITTANCE MEASUREMENTS

Purpose

Acoustic immittance¹ measurements assess the integrity and function of the middle-ear system. These measurements determine middle-ear pressures, tympanic membrane mobility, eustachian tube function, continuity and mobility of the ossicular chain, acoustic reflex threshold and non-organic hearing loss (Northern and Downs, 1974).

Description of Technique²

Acoustic immittance testing is based on the principle that the tympanic membrane and middle-ear structures provide opposition or resistance to the movement of sound energy. The total resistance of the middle-ear structures determines the proportion of sound energy that is absorbed or reflected off the tympanic membrane. Any alteration in the normal state will affect this proportion. The total resistance of the middle ear to the flow of acoustic energy is expressed in a complex ratio called "impedance". Conversely, the mobility of these structures is quantified in units called "compliance". Tympanometry is an objective means of measuring the mobility or compliance of the tympanic membrane during artificially induced changes in air pressure in the external auditory canal. The instrument used in tympanometry is an acoustic-impedance bridge or meter and measurements obtained are expressed graphically in a tympanogram.

The procedures of tympanometry are quite simple. A head set is used that has an earphone and a small probe tip which is inserted into the test ear and hermetically sealed with a small rubber cuff. Most probe tips carry three tubes. Through one a fixed frequency tone is introduced into the ear. The second is connected to a microphone to monitor sound-pressure level. The third is connected to a pump manometer that varies and measures air pressure. Certain modifications permit these functions with only two tubes in the Teledyne Avionics acoustic impedance meter model TA-ID. With this unit the tone is introduced at a given intensity and frequency (226 Hz) and the sound-pressure level in the external auditory canal is monitored while air pressure is artificially varied from +200 to -200 or -400mm water. The tympanogram obtained depends upon the fact that absorption of sound by the tympanic membrane varies inversely with stiffness of the tympanic membrane. Stiffness and acoustic impedance are least when pressure is equal on both sides of the tympanic membrane. Available clinical instruments actually measure acoustic admittance, the reciprocal of impedance. Thus the ease with which energy flow is measured and expressed as acoustic susceptance in milliohms or acoustic compliance in cubic centimeters of a volume of air that has an equivalent compliance. Susceptance and compliance are essentially equivalent at a frequency of 226 Hz.

¹ This term denotes either acoustic impedance or acoustic admittance and is recommended by ASHA (1978).

² Portions of this section have been reproduced from Fernandes, et al., 1978.

Tympanograms can be classified according to their shape, their amplitude when a definable peak is evident and the pressure at which peak compliance occurs. According to the most popular method of interpretation most tympanograms are classified as A, B or C, although other systems have been suggested. Peak compliance of type A tympanograms occurs at or near a pressure of 0. Type A tympanograms are found when the middle ear is normal. Type B tympanograms are flat. Type B tympanograms are found when a middle ear effusion is present or when impacted cerumen prevents movement of the tympanic membrane. Type C tympanograms resemble type A tympanograms but peak compliance occurs at or below a pressure of -100 mm water. A type C tympanogram indicates the presence of reduced pressure in the middle ear, often associated with middle ear effusion. Tympanograms with amplitude reduced to less than 0.3 cc have also been found often to be associated with the presence of middle ear effusions.

The acoustic reflex threshold is the lowest level of sensation at which a sound elicits increased acoustic impedance, ascribed usually to contraction of the stapedius muscle. Since this is a bilateral reflex, its threshold can be determined by presenting the stimulus tone to one ear and recording the lowest intensity at which a change in impedance of the contralateral ear occurs. The acoustic reflex is elicited at the pressure at which the tympanogram indicates peak compliance for the ear presented with the stimulus tone. Absence of an acoustic reflex suggests a conductive loss on either side, sensorineural impairment, or a retrocochlear lesion. Acoustic reflexes normally occur at sensation levels of 70-95 decibels.

Validity

The validity of acoustic immittance measurements in the identification of middle-ear effusion has been tested by a number of investigations. The usual procedure adopted is the comparison of immittance results with established methods of diagnosis.

Table 1 summarizes the results of three studies that estimated the level of agreement between tympanometry (including acoustic reflex) and surgical evidence of middle-ear effusion. Reported overall agreement ranged from 75 to 87 percent. Best agreement between the two measures was found when tympanograms presented flat, gradient curves and negative displacement.

Table 2 presents three investigations which compared the results of tympanometry and otoscopic examination.

TABLE 1
Comparison of Acoustic Immittance with Surgical
Evidence of Middle-Ear Effusion

	Overall Agreement (%)
Brooks (1968)	87
Bluestone et al (1973)	75 - 83
Paradise et al (1976)	86

TABLE 2
Comparison of Acoustic Immittance with Otoscopy

	Overall Agreement (%)	Over Referral (%)	Under Referral (%)
McCandless and Thomas (1975)	93.0	5.8	1.2
Cooper et al. (1975)	75.0	20.9	4.1
Roberts (1976)	69.6	30.1	0.3

Here greater variability in reported agreement is found, ranging from 69.6 to 93.0 percent. Such a variation can be mainly attributed to differences in the pass-fail criteria for tympanometry adopted by each investigator. McCandless and Thomas (1974) defined immittance failure as negative middle-ear pressure below -100 mm water equivalent pressure and the absence of acoustic reflex elicited by a 1000 Hz tone at 100 dB HL. Roberts (1976) adopted more sensitive criteria. Failure was defined as any tympanogram type other than Type A and absence of acoustic reflex upon presentation of either test frequency of 1000 Hz and 2000 Hz at 96 dBHL. The study concluded that these criteria were probably over-sensitive.

Another factor could have produced the variability in estimated agreement between the two measures. Fernandes et al. (1978) report inter-rater reliability of 65 to 79 percent among otolaryngologists performing otoscopic examination for middle-ear abnormality. Jordon (1972) reports a similar lack of consistency. Thus, differences in the reliability of otoscopic examination may have influenced the reported validity of immittance measures in these studies.

The lack of sensitivity of pure tone audiometry in the detection of middle-ear disease is well documented. Eagles et al. (1967) reported that 61 percent of otoscopically abnormal ears presented hearing sensitivity in the normal range. Cohen and Sade (1972) compared the pure tone audiometric threshold levels of 408 children identified as having serous otitis media and found that 50 percent passed conventional hearing screening at 20 dBHL. Brooks (1975) found that hearing loss accompanying serous otitis may be as little as 10-15dB which is well within the pass criteria of audiometric screening (20 - 25dBHL). McCandless and Thomas (1974) compared the level of agreement between otoscopy, tympanometry and pure-tone screening and found that pure-tone screening agreed with otoscopic examination in only 61 percent of cases. This compared with an overall agreement between otoscopy and tympanometry of 91 percent.

Although acknowledging the accuracy of immittance testing in the detection of middle ear effusion, Swartz et al. (1978) indicate that such measures may be over-sensitive and often lead to unnecessary referral. This factor is best attributed to the transitory nature of middle-ear disease and conflicting evidence as to what constitutes abnormal middle-ear pressure. Brooks (1977) and ASHA (1978) have proposed criteria that include an "at risk" classification of failure in which certain cases are retested after initial failure

before referral is made. This feature operates to reduce over-referral by allowing transitory cases to resolve without the risk of ignoring potentially chronic cases.

Reliability and Acceptability

Test-retest reliability of immittance measures is difficult to establish due to the inherently labile nature of middle ear disease. Data on immediate retesting could not be found. Lewis (1975) however, investigated consecutive day retesting and found a maximum daily variation of 35 percent. MacKenzie (1980) identifies features of immittance testing that increases reliability. First, the measures are objective since no response or judgement is required from the subject. The subject must only remain still for a short period of time without vocalizing, swallowing or chewing. Second, the measures are not influenced by ambient noise and can thus be applied in most environments.

Acceptability to individuals being tested is good since the procedures employed are non-invasive and atraumatic. Investigations have reported a maximum of 10 percent of subjects unable to be tested. Ninety percent of unsuccessful attempts were due to inability to obtain an adequate probe-ear seal. (Jerger et al., 1974; Harker and Van Wagoner, 1974; Paradise et. al, 1976; Roberts, 1976; McCurdy, et al., 1976).

APPENDIX 2
SIGNIFICANCE OF MIDDLE EAR DISEASE



SIGNIFICANCE OF MIDDLE-EAR DISEASE

The medical significance of middle ear disease is well documented. Chronic otitis media if untreated can lead to erosion of the tympanic membrane and ossicular chain, adhesive lesions of the middle ear, alterations of the mucosa of the middle ear cavity, formation of cholesteatoma, and bone erosion of the cranial cavity which increases the possibility of otic meningitis. Otitis media is also recognized as a major cause of hearing impairment in young children (Cody, 1977; Fernandes, 1978). The capricious nature of otitis media, however, poses difficult problems both in its diagnosis and treatment. Since the early effects of the disease are often subtle and transitory, many cases may go undetected until more serious symptoms appear. Likewise, minimal hearing loss (less than 25 dB HC) often accompanying recurrent bouts of otitis media has generally not been seriously regarded nor detected by standard audiometric screening procedures.

Recent literature indicates that recurrent middle ear disease and associated minimal hearing loss can have significant educational, developmental, social and psychological consequences (Ling, 1969; Menyuk, 1969; Kaplan, et al., 1973; Holmes and Kuaze, 1960; Goetzinger, 1965; Quigley and Thomure, 1970; Downs, 1975; McCandless and Thomas, 1974; Hamilton, 1973; Matkin, 1976; Howie, 1977; Brooks, 1978). Thus, early identification and intervention is crucial. The transient nature of the disease, however, has encouraged the tendency to allow the condition to resolve spontaneously. While in many cases this is successful, not all cases resolve without intervention and the problem facing any identification program is to determine which cases will and will not resolve. A current approach to this problem favors the identification of an "at risk" population that can subsequently be monitored over time.

Some controversy exists in the medical community as to what constitutes treatable middle-ear disease and the preferred course of treatment. This does not, however, reduce the importance and need for early identification. As ASHA (1978) points out:

"Separate from the medical aspects, identification of children with potential fluctuating hearing loss is felt to be necessary for proper educational management. Although recognizing that further research is necessary for determining the significance and treatment of subtle, middle-ear disorders, screening programs can identify potential at risk populations and, in addition, can presently identify those persons with more obvious middle-ear disease who can, in fact, benefit from medical intervention."



APPENDIX 3

GUIDELINES FOR ACOUSTIC IMMITTANCE SCREENING OF
MIDDLE-EAR FUNCTION (ASHA, 1978)
AND IDENTIFICATION AUDIOMETRY (ASHA, 1974)



GUIDELINES FOR ACOUSTIC IMMITTANCE
SCREENING OF MIDDLE-EAR FUNCTION

NOTE: This set of guidelines was approved by the ASHA Legislative Council in November, 1978 and was developed by the following personnel: Q.C. Berry, G.A. Del Polito, D. Katz, J.R. Madell, W.O. Olsen, P.S. Williams and M. Seidemann, Chairman. The Guidelines presented here are abridged and reproduced from Clinical Guidelines in Language, Speech and Hearing Services, 1980.

The guidelines concern the parameters of measurement and do not discuss specific measurement techniques such as type of ear tips, insertion of probe-tip assembly, instructions to person being tested, color of pen recordings and so forth. These are left to the discretion of the examiner and most are usually discussed in the equipment manual provided by the manufacturer.

Equipment

Acoustic imittance instruments for screening programs should have as a minimum the capability for tympanometry and for monitoring an acoustic reflex at a specified intensity level.

The instrumentation should contain an automatic recording system which produces a permanent record of the test results.

Calibration

Pending adoption of ANSI standards for calibration of imittance instruments, electroacoustic calibration procedures should be performed at least monthly according to the manufacturer's specifications. During active periods of screening, test cavity calibration checks routinely for obstructions. Further assessment of the system is necessary when imittance results appear spurious.

The acoustic reflex eliciting signal should be checked monthly and be calibrated according to the ANSI S3.6-1969 requirements for pure-tone calibration of standard earphones. For ipsilateral reflex stimuli, a 2 cc coupler must be used.

Since there is presently no available accompanying equipment provided by the manufacturer for determining accuracy of the pressure system, it is recommended that a U-tube water manometer be used at least monthly.

Calibration of the automatic recording unit should be performed according to manufacturer's specification at least monthly. Daily calibration checks of all systems should be performed during active screening periods.

Pump System

An automatic constant-rate pump system with a recording system is recommended. The instrumentation may include an automatic recording system in order to reduce screening time, reduce the possibility of recording error by nonprofessionals, and produce a permanent record of test results.

Air-Pressure Range

The recommended air-pressure range used should cover a minimum of +100 to -300 mm H₂O. The greater range in the negative direction is recommended since abnormalities in children are usually revealed in this dimension. Determining the pressure status beyond -300 mm H₂O would contribute little to the screening data and would unnecessarily increase screening time. Although negative pressure status is known to fluctuate over short periods of time (Lewis et al. 1975), such pressures pose sufficient threat to the integrity of hearing (Flisberg et al, 1963; Cooper et al, 1975) to warrant re-screening and at-risk classification.

Probe Tone Frequency

A low-frequency probe-tone between 220 and 300Hz is recommended since the bulk of screening data used the low-frequency and there is insufficient information on screening with higher frequencies. Also, the low-frequency probe-tone is the only one universally available on present screening equipment.

Rate and Direction of Air-Pressure Change

There are insufficient data to recommend guideline procedures. In the interim a consistent approach within each program is recommended for best test-retest comparison and reliability.

Measurement Units

ANSI guidelines for measurement units are not available at present. In the interim a consistent approach within each program is recommended.

Frequency for Acoustic Reflex Eliciting Signal

The recommended eliciting signal is a pure tone of 1000 Hz. This frequency is chosen because it is less likely to be influenced by mild negative pressure effects for lower frequencies, which may elevate reflex eliciting levels, and because it is less likely to be viewed as a hearing screener for high-frequency hearing loss. In addition, this frequency appears to have a lower acoustic reflex threshold than most other pure-tone frequencies (Jepsen, 1963; DiSogra, 1978), and it was found to be the most consistent eliciting frequency (compared to 500, 2000, 4000 Hz) to show a reflex in screening program with children ages 6-14 years (DiSogra, 1978).

Level of Acoustic Reflex Eliciting Signal

Levels recommended are a 100 dB HL signal for contralateral stimulation or a 105 dB SPL signal for ipsilateral stimulation.

The acoustic reflex in normal ears is elicited between 75-100 dB HL for pure-tones (Peterson and Liden, 1972). Negative pressure levels are known to elevate acoustic reflex thresholds (Peterson and Liden, 1972; Skinner et al, 1977). Skinner et al (1977) found the mean reflex threshold elevated by 2.5 dB for ipsilateral stimulation and 5 dB for contralateral stimulation. Although wishing to compensate for negative pressure effects, the use of

unusually high intensity levels can lead to artifact and may create a startle response. Therefore, it is recommended that a level at the upper limits of the normal range with an additional compensating level for mild negative pressure effects be used.

Pressure for the Acoustic Reflex Test

The acoustic reflex test should be administered at the tympanogram peak pressure point when it is identified in order to maximize the possibility of obtaining a response, or at ambient air pressure when no pressure peak can be identified.

Criteria for Pass-Fail

For screening purposes, middle-ear pressure, and presence or absence of the acoustic reflex, are the only factors involved in referral criteria. Static immittance values are not included in these criteria due to the large variability in this parameter as reported in the literature (Jerger, 1970; Feldman, 1974).

Pass-fail and referral criteria are summarized below:

I. PASS	Middle-ear Pressure or Normal ^o or Mildly positive/negative ^{oo} and Acoustic Reflex Present ^{ooo}	Cleared; no return
II. AT RISK	Middle-ear Pressure Abnormal ^{oooo} (and Acoustic Reflex present) or Acoustic Reflex Absent (and middle-ear pressure normal or mildly positive/negative)	Retest in 3-5 weeks a) If Tymp. and AR fall into Class I, PASS b) If Tymp. or AR remain in Class II FAIL and refer.
III. FAIL	Middle-ear Pressure Abnormal and Acoustic Reflex Absent	Refer

^o Normal: Pressure peak in range ± 50 mm H₂O.

^{oo} Mildly Positive/Negative: $+50$ to $+100$ mm H₂O^o, -50 to -200 mm H₂O.

^{ooo} Present: Pen or meter needle deflection judged to be coincident with the reflex eliciting stimulus at levels of 100 dB HL for contralateral stimulation, 105 dB SP. for ipsilateral stimulation at 1000 Hz.

^{oooo} Abnormal peak outside the ranges described for Classification I.

GUIDELINES FOR IDENTIFICATION AUDIOMETRY

NOTE: This set of guidelines was approved by the ASHA Legislature Council in November, 1974 and was developed by J.B. Chaitin, N.T. Hopkinson, J.I. Graham, S.G. Shoeny, F.L. Sondag, V.W. Nyers, R.M. McLaughlin, and W.R. Wilson, Chairman. The Guidelines presented here consist only of the summary section of the complete guidelines and have been reproduced from Clinical Guidelines in Language, Speech and Hearing Services, 1980.

Summary

ASHA recommends a manually administered, individual, pure-tone, air-conducted screening procedure for accomplishing identification audiometry. The purpose of this procedure is to identify rapidly and effectively those persons with hearing impairment that interferes with communication or that has the potential for interfering with communication. The procedure is designed to be used with children as young as three-years old, although it is applicable for use with adults.

The recommended identification audiometry procedure is as follows. Audiometric screening should be at 20 dB HL (re: ANSI-1969) at the frequencies of 1000 Hz and 2000 Hz and 25 dB HL at 4000 Hz. Failure to respond at the screening level at one or more frequencies in either ear is the criterion for failure. An audiometric re-screening should be administered the same day or not later than within one week to all persons failing the initial screening. An audiologist should administer an audiologic evaluation to persons failing the re-screening. If a hearing impairment is identified by audiometric evaluation, referrals should be made to meet the person's habilitation, educational and medical needs.

Several procedural considerations are vital to implementing successfully the ASHA Guidelines for Identification Audiometry. An audiologist should conduct or supervise an identification audiometry program, although non-professional support personnel may be used for the screening procedures after appropriate training. Careful instructions are very important, particularly for young children. Ambient noise levels should not exceed 50 dB SPL at 1000 Hz, 58 dB SPL at 2000 Hz, and 76 dB SPL at 4000 Hz using a sound level meter with octave band filters centered on the screening frequencies. Audiometric equipment should initially meet all the ANSI S3.6 - 1969 specifications and be checked at least annually. The sound pressure output at the phones should be checked at least every three months, and listening checks for any gross malfunctions should be made daily. Finally, appropriate reporting of screening results should avoid diagnostic conclusions and encourage further evaluation for persons not passing the screening procedures.

APPENDIX 4

**STANDARD RECORD FORMS USED IN THE LEDUC-STRATHCONA
IMMITTANCE-HEARING SCREENING PROGRAM**

EDUC-STRATHCONA health unit

HEARING & IMPEDANCE SCREENING

Date _____

Test By _____

Name _____

Initial

Reflex:

Test _____

Right _____

Refer for further

Evaluation _____

Birth Date _____

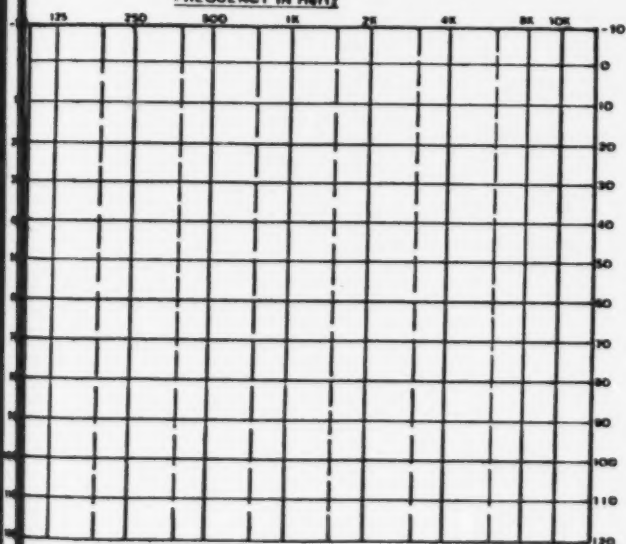
Re-test _____

Left _____

Refer to Family

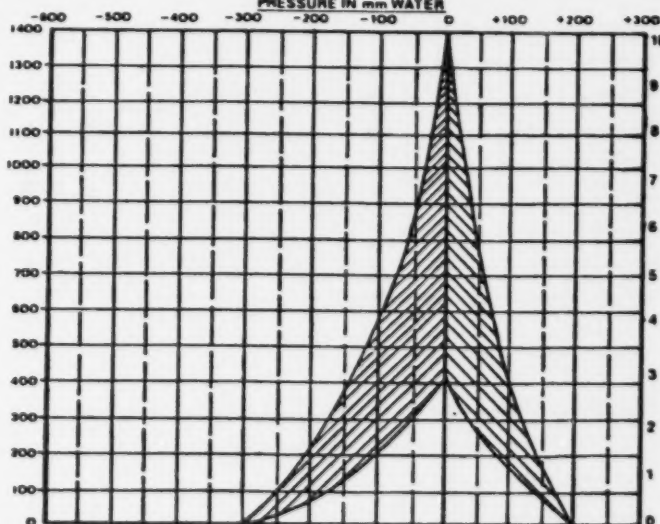
Doctor _____

AUDIOGRAM
FREQUENCY IN Hertz



TYMPANOGRAM

PRESSURE IN mm WATER





leduc-strathcona health unit

AUDIOLOGICAL REPORT FORM

NAME _____

COMMENTS _____

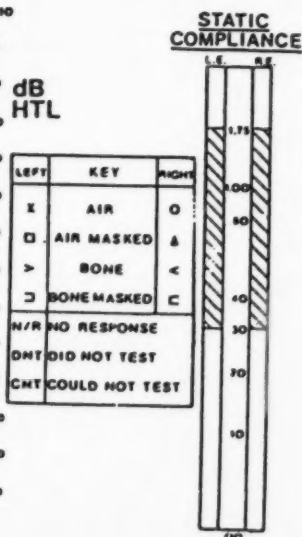
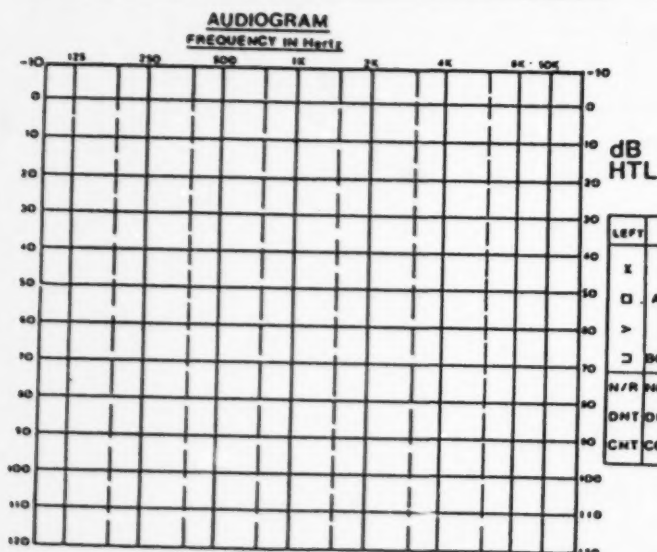
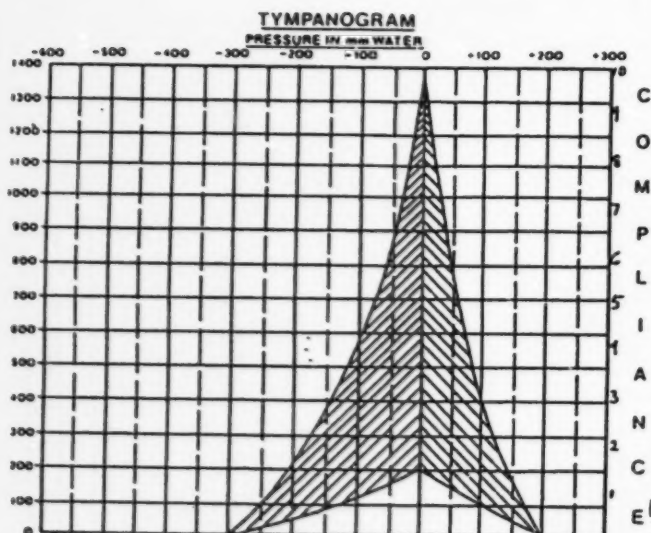
ADDRESS _____

B. D. _____ PHONE _____

SCHOOL/EMPLOYER _____

REFERRAL SOURCE/NURSE _____

DATE _____ DR. _____



MIDDLE EAR PRESSURE
Left _____ Right _____
IN mm H₂O

ACOUSTIC REFLEX

	750	1000	2000	4000
R				
L				

HISTORY: _____

Referred to Doctor _____

FOLLOW-UP INFORMATION

_____ Has been seen by G.P. _____
_____ E.N.T. _____
_____ Audiologist _____

_____ Action taken (by Dr.)

_____ No action

_____ Medication _____

_____ Referred to E.N.T.

_____ Aerating Tubes

_____ Removal of wax

_____ Other action _____

_____ No action since last test (by Client)



APPENDIX 5

SCREENER QUESTIONNAIRE

SUMMARY OF RESPONSES TO THE SCREENER QUESTIONNAIRE



SUMMARY OF RESPONSES TO THE SCREENER QUESTIONNAIRE

A response rate of 55 percent (6 of 11 nurses responding) to the questionnaire was obtained due to staff turnover.

<u>QUESTION</u>	<u>RESULTS</u>
1.0 Are parents routinely contacted upon initial screen failure?	YES (5) NO (1)
1.1 If YES, how?	By phone (3) By note and phone (2)
1.2 If NO, why?	Only contacted parent if child required follow-up testing or direct referral to physician (1)
2.0 Are parents routinely contacted upon re-screen failure?	YES (6) NO (0)
2.1 If YES, how?	By phone (6)
3.0 Are teachers routinely contacted upon initial screen failure?	YES (6) NO (0)
3.1 If YES, how?	Verbal report (6) A list of pass/failures is provided.
4.0 Are teachers routinely contacted upon re-screen failure?	YES (6) NO (0)
4.1 If YES, how?	Verbal report (4) Verbal report and note (2)
5.0 When a direct referral to the physician is indicated, how is information provided to the physician?	Parent contacted, instructed to have child examined and provided with written results/referral to present to physician (4) As above but written results/referral mailed to family physician (2) Comments: Going through speech therapist gets best results (2) Physician could indicate no problem present (2)

<u>QUESTION</u>	<u>RESULTS</u>
6.0 Is adequate feedback provided to you by speech pathologists regarding cases referred for follow-up testing?	YES (5) NO (1)
6.1 If NO, how might this be improved?	Should provide feedback on cases not scheduled due to no-show or refusal (1)
7.0 Is it generally possible to retest initial failures within the timelines prescribed by the program criteria?	YES (2) NO (4)
7.1 If NO, why?	Scheduling problems (4) including: 1) absenteeism 2) lack of space in the school 3) only certain days are booked at each school 4) screening occurs in October and follow-up testing coincides with Christmas break.
8.0 What method(s) do you use to schedule retesting of initial failures?	Screening and re-testing conducted during regular school visits as part of the total nursing program (6)
9.0 Do you feel conducting immittance screening consumes too much of your schedule.	YES (0) NO (6)
	Comments: Only time consuming if there's a problem (2)
	Need more experience (1)
	Feel it is worthwhile (1)
	Would not like to go back to pure-tone only testing (2)
10.0 What do you feel are the advantages/ benefits of the program?	Provides more information and more accurate referrals (3)
	Identifies cases that would not be detected by pure-tone screening only (4)
	Parents are appreciative (1)

QUESTION

11.0 What do you feel are the disadvantages/shortcomings of the program?

RESULTS

Recurrent problems are identified (1)

Phoning parents (1)

Paper work involved in referral (2)

Not clear on referral procedures for "border line" cases (2)

Physicians do not take action in some cases (1)

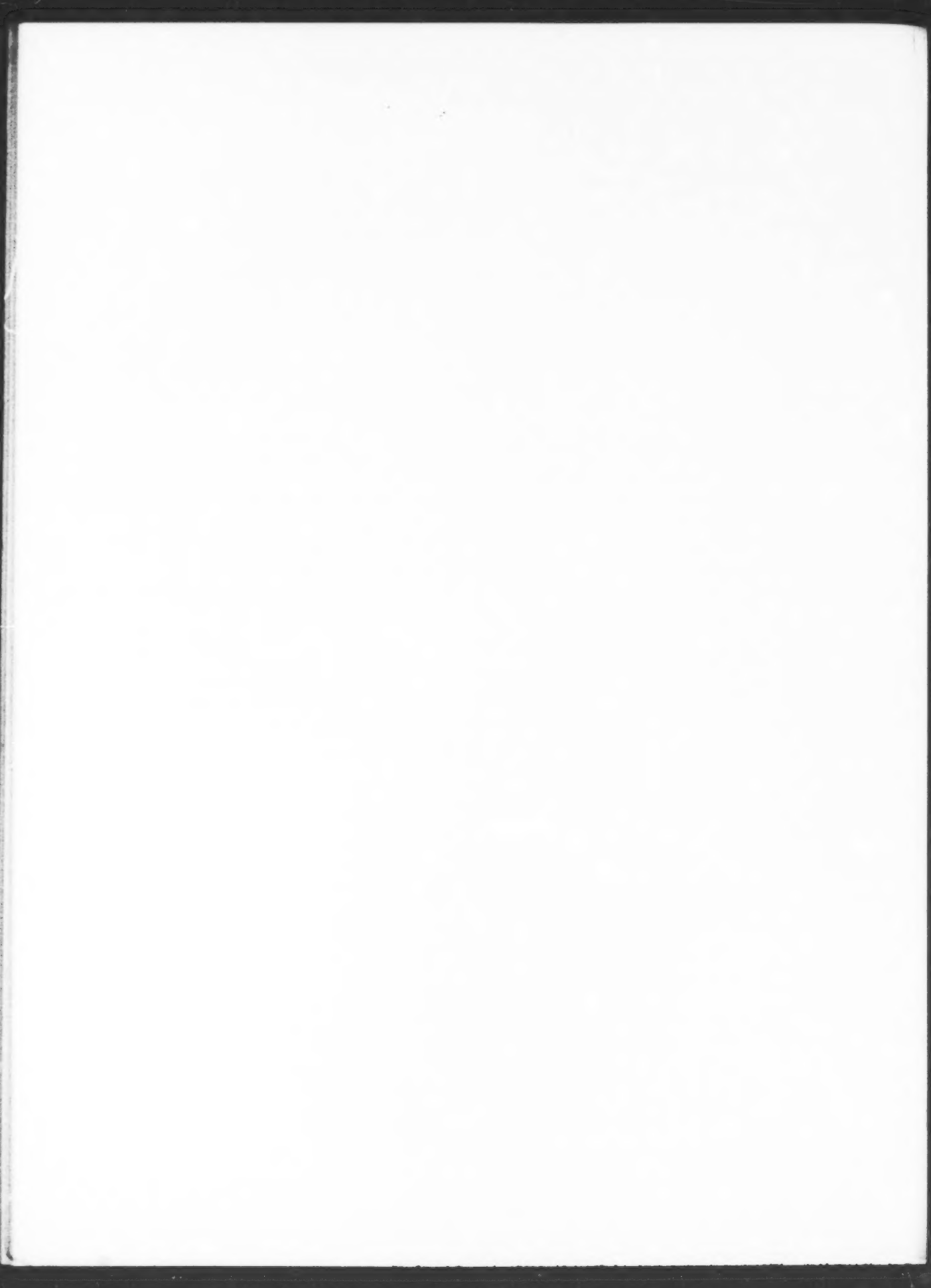
Not enough equipment (1)

Finding room at the schools is difficult (1)

Difficulty obtaining seal (2)

Need better provision of information to the schools (1)

Duplication of pure-tone screening by public school therapists (1)



APPENDIX 6
PROGRAM AND CLIENT DATA

HS14A



PROGRAM AND CLIENT DATA

1.0 Program Summary

1.1 Number of children screened: 1149

1.2 Number of initial screening failures: 344

This represents 29.9% of the total sample.

1.3 Number recommended for re-screening: 255

This represents 22.2% of the total sample and 74.1% of all initial screening failures.

1.4 Number re-screened: 168

This represents 14.6% of the total sample. Note that the figure 168 includes 43 cases who received re-screening when other services were recommended. The total number of appropriate re-screens equals 125 which represents 10.9% of the total sample and 49.0% of all cases recommended for re-screening.

1.5 Number of re-screening failures: 80

This represents 7.0% of the total sample and 47.6% of all cases re-screened. Since 110 cases did not receive re-screening when recommended, seven percent is considered and estimate of the re-screen failure rate for the total sample.

1.6 Number recommended for physician referral and/or follow-up testing after initial screening failure: 78

This represents 6.8% of the total sample and 22.7% of all cases failing initial screening.

1.7 Number recommended for physician referral and/or follow-up testing after re-screening failure: 75

This figure includes 43 cases who were referred twice, that is, both after initial and re-screening failure. A total of 32 cases were recommended on the basis of re-screen failure only. This represents 2.9% of the total sample and 40.0% of all cases failing re-screening.

(Note: In total, 110 cases were recommended for physician referral and/or follow-up testing. This represents 9.6% of the total sample.)

1.8 Number receiving follow-up testing: 80

This represents 7.0% of the total sample and 72.7% of all cases recommended for follow-up testing.

1.9 Number of follow-up test failures: 49

This represents 4.3% of the total sample and 61.3% of all cases receiving follow-up testing.

1.10 Initial screen failures by month tested (N=344)

<u>Month Tested</u>	<u>Cases</u>	<u>%</u>
January	10	2.9
February	8	2.3
March	26	7.6
April	20	5.8
May	16	4.7
June	10	2.9
July	20	5.8
August	2	0.5
September	20	5.8
October	169	49.1
November	37	10.8
December	6	1.7
	(344)	(100.0)

1.11 Re-screen failure by month tested (N=168)

<u>Month Tested</u>	<u>Cases</u>	<u>%</u>
January	42	25.0
February	5	3.0
March	3	1.8
April	11	6.5
May	10	6.0
June	18	10.7
July	0	0.0
August	1	0.6
September	4	2.4
October	13	7.7
November	41	24.4
December	20	11.9
	(168)	(100.0)

1.12 Average time lapse between initial and re-screening: 13 weeks

Time between initial and re-screening ranged from 1-63 weeks, with 25% of cases re-screened within 3-5 weeks as prescribed.

1.13 Average time lapse between initial screening and follow-up: 14 weeks

Time between initial screening and follow-up testing ranged from 1-60 weeks with 47.5% of cases tested within 8 weeks of initial screening.

1.14 Average time lapse between re-screening and follow-up: 8 weeks

Time between re-screening and follow-up testing ranged from 1-30 weeks with 70% of cases tested within 8 weeks of re-screening.

2.0 Initial Screening Client Data

2.1 Cases failed by reason for failure (N=344)

<u>Reason Failed</u>	<u>Cases</u>	<u>%</u>	<u>% of Total Sample (N=1149)</u>
Audiometry only	81	23.5	7.0
Immittance only	119	34.6	10.4
Audio and Immittance	91	26.5	7.9
Incomplete	53	15.4	4.6
	(344)	(100.0)	(29.9)

2.2 Recommended follow-up for cases failed (N=344)

<u>Follow-up Recommended</u>	<u>Cases</u>	<u>%</u>	<u>% of Total Sample (N=1149)</u>
Re-screen	255	74.1	22.2
Refer to physician and follow-up testing	54	15.7	4.7
Refer for follow-up testing	24	7.0	2.1
Review on request	11	3.2	0.9
	(344)	(100.0)	(29.9)

2.3 Initial immittance screening results reported in peak-middle ear pressure for EARS screened (N=2298)

<u>Immittance Result</u>	<u># Ears</u>	<u>% of Ears Failed or "At Risk"</u>	<u>% Total Sample (N=2298)</u>
Pass (± 100 mm)	1914	-	83.3
At Risk (-101 to -200 mm)	171	49.1	7.4
At Risk (-201 to -400 mm)	87	25.0	3.8
Failure (less than -401 mm or no compliance peak)	90	25.9	3.9
Could not obtain seal	16	-	0.7
Would no cooperate	9	-	0.4
Tubes/Myringotomy/Infection	11	-	0.5
	(2298)	(100.0)	(100.0)

3.0 Re-screen Client Data

3.1 Cases failed by reason for failure (N=80)

<u>Reason Failed</u>	<u>Cases</u>	<u>%</u>	<u>% of Cases Re-screened (N=168)</u>
Audiometry only	10	12.5	6.0
Immittance only	35	43.7	20.8
Audio and Immittance	30	37.5	17.8
Incomplete	5	6.3	3.0
	(80)	(100.0)	(47.6)

3.2 Recommended follow-up for cases failed (N=80)

<u>Follow-up Recommended</u>	<u>Cases</u>	<u>%</u>
Refer to physician and follow-up testing	50	62.5
Refer for follow-up testing	25	31.3
Review on request	5	6.2
	(80)	(100.0)

3.3 Re-screen immittance results reported in peak middle-ear pressure for EARS screened (N=336)

<u>Immittance Result</u>	<u># Ears</u>	<u>% of Ears Failed or "At Risk"</u>	<u>% Ears Re-screened (N=2298)</u>
Pass (± 100 mm)	222	-	66.1
At Risk (-101 to -200 mm)	41	36.0	12.2
At Risk (-201 to -400 mm)	31	27.2	9.2
Failure (less than -400 mm or no compliance peak)	39	34.2	11.6
Could not obtain seal	2	1.7	0.6
Would not cooperate	1	0.9	0.3
	(336)	(100.0)	(100.0)

4.0 Follow-up Testing Client Data

4.1 Cases failed by reason for failure (N=49)

<u>Reason Failed</u>	<u>Cases</u>	<u>%</u>	<u>% of Cases Received Follow-up Testing (N=80)</u>
Audiometry only	7	14.3	8.8
Immittance only	14	28.6	17.5
Audio and Immittance	28	57.1	35.0
	(49)	(100.0)	(61.3)

4.2 Follow-up testing: immittance results reported in peak-middle ear pressure for EARS tested (N=160)

<u>Immittance Result</u>	<u># Ears</u>	<u>% or Ears Failed or "At Risk"</u>	<u>% Ears Follow-up Total (N=2298)</u>
Pass (± 100 mm)	73	-	45.6
At Risk (-101 to -200 mm)	28	32.1	17.5
At Risk (-201 to -400 mm)	20	23.0	12.5
Failure (less than -400 mm or no compliance peak)	32	36.8	20.0
Tubes, myringotomy, infection	4	4.6	2.5
Could not obtain seal	1	1.1	0.6
Would not cooperate	2	2.3	1.3
	(160)	(100.0)	(100.0)

4.4 Recommended follow-up for cases failed (N=49)

<u>Follow-up Recommended</u>	<u>Cases</u>	<u>%</u>
Review in 3-12 months	16	32.7
Refer to physician and review in 3-12 months	25	51.0
Review on request	8	16.3
	(49)	(100.0)

4.5 Follow-up test results: cross tabulation of impedance and pure-tone thresholds for EARS tested (N=160)

		<u>Impedance Results*</u>				
<u>Pure-tone Results**</u>		<u>±100 mm</u>	<u>-100 to -200 mm</u>	<u>-201 to -400 mm</u>	<u>less than -400 mm</u>	<u>Unable to Test</u>
	0 - 15 dB	65	22	13	1	3
	16 - 25 dB	3	3	5	16	2
	26 - 40 dB	1	0	1	6	0
	41 - 65 dB	0	0	0	2	0
	Unable to test	4	3	1	7	2

* Impedance results reported in peak middle-ear pressure (mm H₂O) for EARS tested.

** Pure-tone results reported as pure-tone average of 500 Hz, 1000 Hz and 2000 Hz in decibels for EARS tested.

5.0 EARS "At Risk" or Failing BOTH Initial and Re-screening of Impedance as a Function of Time Interval in Weeks Between the Two Screenings (N=106)

<u>Number of Weeks Between Initial and Re-screen</u>	<u>Number of EARS Failing</u>	<u>%</u>
2 - 8 weeks	52	49.1
9 - 17 weeks	39	36.8
18 - 47 weeks	15	14.1
	(106)	(100.0)

* Average interval in weeks = 12.5

6.0 EARS "At Risk" or Failing Initial Impedance Screening that Passed Re-Screening as a Function of Time Interval in Weeks Between the Two Screenings (N=102)

<u>Number of Weeks Between Initial and Re-screen</u>	<u>Number of EARS Failing</u>	<u>%</u>
2 - 8 weeks	51	50.0
9 - 17 weeks	35	34.3
18 - 63 weeks	16	15.7
	(102)	(100.0)

* Average interval in weeks = 12.0

7.0 EARS "At Risk" or Failing BOTH Initial Screening and Follow-up Impedance as a Function of Time Interval in Weeks Between the Two Testings (N=81)

<u>Number of Weeks Between Tests*</u>	<u>Number of EARS Failing</u>	<u>%</u>
2 - 8 weeks	22	27.1
9 - 17 weeks	21	25.9
18 - 57 weeks	38	47.0
	(81)	(100.0)

* Average interval in weeks = 14.4

8.0 EARS "At Risk" or Failing Initial Impedance Screening that Passed Follow-up Impedance Testing as a Function of Time Interval in Weeks Between the Two Tests (N=38)

<u>Number of Weeks Between Tests*</u>	<u>Number of EARS Passed</u>	<u>%</u>
2 - 8 weeks	12	31.6
9 - 17 weeks	15	39.5
18 - 57 weeks	11	28.9
	(38)	(100.0)

* Average interval in weeks = 14.2

APPENDIX 7

EXTERNAL REVIEW

SUMMARY OF COMMENTS AND RECOMMENDATIONS



EXTERNAL REVIEW: SUMMARY OF COMMENTS AND RECOMMENDATIONS

The present Report has been reviewed by three audiologists and the comments and recommendations for improvement of the program made by each are summarized below:

Dr. Paul Kileny and Mr. Chet DesRoches:

1. Recommend the program be coordinated by a qualified clinical audiologist.
2. Suggest a longer period for training screeners is required (i.e. more than a one-day workshop).
3. Recommend the pressure indicator and compliance in equivalent volume (cubic centimeters) be checked and calibrated daily and that the elevation of Edmonton (700 meters above sea level) be taken into consideration when performing such calibration.
4. Recommend three elements be considered in the pass-fail criteria for immittance screening: pure-tone results, peak middle-ear pressure and presence or absence of acoustic reflex. Referral to physician and/or audiologist should be made if the patient presents anomalies in two out of the three criteria following at least one re-test.
5. Regarding information exchange between screening/follow-up personnel and diagnostic personnel, the following comment was made:

When a patient is referred to a physician and it is considered that a diagnostic audiological workup is necessary, this could be incorporated in the referral letter as a suggestion, i.e. "if needed we would appreciate referral to an audiology clinic." It is very difficult to assess your program in the absence of consistent feed-back from physicians. In order to assess the pass-fail criteria established in this program, a pilot project should have been undertaken incorporating no more than 100 patients, and those who would have "failed" the screening should have been referred to two or three specific physicians in order to maintain consistency of clinical judgment. For validity's sake, it would have been seen by two physicians and each physician would have examined the patient "blindly".

6. Suggest the "at risk" percentage following initial screening should approximate 10-15%. Thus, ± 100 mm water as the peak middle-ear pressure cut-off generates a high proportion of false positives.
7. Suggest that if the intention of the program was to deal with the age group presenting the highest incidence of otitis media, the age group chosen would have to be younger than $4\frac{1}{2}$ to $5\frac{1}{2}$, i.e. highest incidence is reported for the 6-24 month range.

8. Suggest it is desirable that the program utilize equipment with automatic recording capability for tympanometry and acoustic reflex.

Mr. Ned Kramp

1. Recommends the retention of the ± 100 mm H₂O cut-off for peak middle-ear pressure with the addition of a simple test for Eustachian tube function. He states:

We are aware that the Eustachian tubes are the sole mechanism by which the middle ear pressures are controlled. If a Valsalva procedure were inserted into your testing for all children who exhibited middle-ear pressure between -100 and -200 mm H₂O, the procedure for administering the Valsalva procedure would involve very little "extra time in the screening process. In the case of the MADSEN ZS76 which was used in your program, the Valsalva procedure would be performed at the time you establish peak middle-ear pressure. It is simply the procedure whereby the child is asked to close the mouth, pinch their nose and blow, which in effect causes high positive pressure in the nasopharyngeal region. If the procedure reduced (Positive Valsalva) the negative middle-ear pressure below -100 mm H₂O, then the previous higher negative peak middle-ear pressure could be discounted and a "pass" for the immittance portion of the testing would be noted. I have modified your table which would reflect the Pass-Fail Criteria and Follow-up model with the Valsalva procedure inserted.

The modified pass-fail criteria as recommended appear on the following page.

PASS-FAIL CRITERIA AND FOLLOW-UP MODEL

CLASSIFICATION	RESULTS OF INITIAL SCREEN	DISPOSITION
I. PASS	Middle-ear Pressure: ± 100 mm H ₂ O and Hearing Screen Pass	CLEARED: NO RETURN
	Middle-ear Pressure: -101 to -200 mm H ₂ O prior to Valsalva Procedures; with positive Valsalva and Hearing Screen Pass.	CLEARED: NO RETURN
II. AT RISK	Middle-ear Pressure: -101 to -200 mm H ₂ O and Hearing Screen Fail, and negative Valsalva.	RETEST IN 3-5 WEEKS
	Middle-ear Pressure: -201 to -400 mm H ₂ O and Hearing Screen Pass	a) If tympanogram and hearing screen = CLASS I, PASS.
		b) If tympanogram and hearing screen = CLASS II, REFER IMMEDIATELY FOR FOLLOW-UP TESTING.
		c) If tympanogram and hearing screen = CLASS III, REFER IMMEDIATELY TO PHYSICIAN AND FOLLOW-UP TESTING.
	or	
	Middle-ear Pressure: -201 to -400 mm H ₂ O and Hearing Screen Fail	REFER IMMEDIATELY FOR FOLLOW-UP TESTING.
III. FAIL	Middle-ear Pressure: outside -400 mm H ₂ O (or no compliance peak) and Hearing Screen Pass or Fail	REFER DIRECTLY TO PHYSICIAN AND FOLLOW-UP TESTING.

